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ABSTRACT

A cognitive theory of interest is proposed and tested that will allow for predicting the degree to which any informational environment is perceived as interesting. This theory is the knowledge-schema theory of cognitive interest (KST) (A. Yarlas, 1998). The KST states that when learning is produced by information in an environment through either schema enhancement or schema modification, that information will be perceived as interesting. Two experiments involving 152 undergraduates and 206 undergraduates, respectively, provide evidence for the predictions of the KST regarding the direct effect of learning on interest. Across both experiments, interest varied in the expected direction as a function of both expectedness of outcomes and type of information. Interest was higher for passages containing unexpected outcomes than for those containing expected outcomes, as the KST predicted. Both experiments support the idea that degree of learning resulting from either schema enhancement or modification predicts the degree of interest for an informational environment. Two appendixes contain the target passages used in both experiments. (Contains 7 figures and 35 references.) (SLD)

Learning as a Predictor of Situational Interest

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The psychological concept of interest, or interestingness[1], and how it relates to knowledge and learning has been discussed sporadically by psychologists and educational researchers throughout the last century. In the early part of the twentieth century, a number of educational philosophers discussed the importance of piquing and maintaining the interest of students in the classroom (e.g., Arnold, 1910; De Garmo, 1902; Dewey, 1913). The philosopher John Dewey, in his book Interest and Effort in Education, claimed "The major difficulty with our schools is that they have not adequately enlisted the interests and energies of children in school work" (Dewey, 1913, p. vii). Decades later, other psychologists, such as Thorndike (1935) and Bartlett (1932), stressed the importance of appealing to interest for increasing learning and memory. The Behavioristic approach to psychology quashed further study on the role of interest in learning, and for almost fifty years, with the exception of the seminal work by Daniel Berlyne and his students, interest was mostly ignored as a variable of study. Even with the cognitive revolution beginning in the 1960's, interest remained a dormant variable; most research focused on how information was processed without concerns of why certain information might be processed differently than others due to affective variables and motivational variables such as interest.

In the last fifteen years, however, there has been a greatly renewed interest among cognitive and educational researchers on the role that interest plays in learning. There is large body of experimental evidence showing that increased amounts of interest leads to faster reading times (Graesser & Riha, 1984; Shimoda, 1993, Wade, Schraw, Buxton, & Hayes, 1993), better comprehension (Bernstein, 1955; Schraw, Bruning, & Svobada, 1995), increased depth-of-processing (Anderson, Wilkinson, & Mason, 1991), higher levels of mathematics achievement (Jennings, Jennings, Richey, & Dixon-Krauss, 1992), increased transfer of learning (Lepper & Cordova, 1992; Parker & Lepper, 1992), and better recall and recognition of information (e.g., Anderson, Shirey, Wilson, & Fielding, 1987; Garner, Alexander, Gillingham, Kulikowich, &

[1]The type of interest that will be discussed in this paper corresponds to what has been called situational interest, which is driven by characteristics of an informational environment and generalizes across people, as opposed to individual interest, which is a person's domain-specific, enduring preferences; see Hidi (1990) and Mitchell (1993) for a more detailed discussion of this distinction.

Brown, 1991; Garner & Gillingham, 1991; Garner, Gillingham, & White, 1989; Hidi & Baird, 1986; Sadoski, Goetz, & Fritz, 1993; Shirey & Reynolds, 1988; Wade & Adams, 1990).

The effort to spell out the cognitive factors that contribute to interest has been somewhat less successful. Several specific hypotheses regarding the causes of cognitive interest have been proposed and tested. Still, there is no established cognitive theory that can predict degree of interest across a wide range of informational environments. The purpose of the current paper is to propose and test a cognitive theory of interest that will allow for predicting the degree to which any informational environment is perceived as interesting.

The theory that will be proposed and tested is the <u>knowledge-schema theory of cognitive interest</u> (KST; Yarlas, 1998). This model assumes that interest for an environment varies as a function of how informative the environment is. By informative, I am referring to whether an environment provides a person with both useful and comprehensible information that can be meaningfully processed and incorporated into a person's knowledge structures, or schemas. This incorporation can take two forms: 1) <u>schema enhancement</u>, or <u>schema elaboration</u>, which occurs when new information fills in empty slots of a pre-existing schema, thus increasing one's knowledge while maintaining the schematic structure (i.e., assimilation of new information into a current schema), and 2) <u>schema modification</u>, or <u>schema change</u>, which occurs when new information leads to a radical restructuring of a pre-existing schema, thus increasing one's knowledge by changing the schematic structure (i.e., accommodation of a schema to fit new information). The KST states, then, that when learning is produced by information in an environment through either schema enhancement or schema modification, that information will be perceived as interesting.

The knowledge-schema theory of cognitive interest integrates a number of hypotheses that have been proposed to explain the causes of interest. In his work on interest for perceptual stimuli, Berlyne (1971, 1974) found that variations of collative properties, such as novelty and complexity, in a stimulus had differential effects on perceived interest. Specifically, when the amounts of novelty or complexity were low or high, participants showed little interest, but when these collative properties were at moderate levels, interest in the stimuli was increased. Berlyne explained these findings with his arousal-jag hypothesis, claiming that interest was a result of an initial period of arousal due to some disorientation, followed by an assimilation of the information. Thus, when arousal is not induced (when the levels of the collative properties are low) or when the information cannot be assimilated (when the levels of the collative properties are high), interest is low; when both arousal and eventual assimilation are possible (when the levels of the collative properties are moderate), then interest should occur.

While Berlyne did not frame his hypothesis in terms of learning, the analogy is quite apparent. When attending to information that is low in novelty or complexity (i.e., the information is very familiar or not challenging), little or no schematic enhancement or modification should occur, as this information does not add meaningfully to a person's current knowledge. When encountering information that is quite high in novelty or complexity (i.e., the information is very unfamiliar and too challenging), again little or no schematic enhancement or modification should occur, as this information cannot be understood and processed in terms of a person's current knowledge. However, when information is at some moderate level of these collative properties, schema enhancement or modification are likely to occur; this information is understandable in terms of one's current knowledge structures, but provides something new and different that will meaningfully add to or change this knowledge.

Another hypothesis incorporated within the knowledge-schema theory of cognitive interest is Kintsch's (1980) prior knowledge hypothesis, which states that interest in a textual passage will be low when the reader is either completely unknowledgeable or completely knowledgeable about the content of the material, but will be high when the reader possesses some intermediate amount of knowledge about the content. This hypothesis maps well onto the predictions of the KST. When a person is completely unknowledgeable, they have no existing schematic framework upon which to assimilate the incoming information, and thus schematic enhancement should be minimal. When a person is completely knowledgeable, the incoming information is redundant to their current knowledge, and again schematic enhancement should be minimal.

When a person is moderately knowledgeable, however, they have an existing, yet incomplete schematic framework upon which the incoming information can be easily assimilated, and thus will be able to optimally process and learn from the passage. Again, the degree of learning due to schema enhancement that is induced by an informational environment seems predictive of the resulting interest in that environment.

Hypotheses that posit unexpectedness of information as a cause of interest are also consistent with the knowledge-schema theory of cognitive interest. Schank (1979) and Mandler (1982) proposed that unexpected events, such as surprises or anomalies, are inherently interesting, since this information disrupts the normal unfolding of a script, or schema. Kintsch (1980), however, stated that surprise or unexpectedness alone does not drive interest, but that there must also be a potential for resolution, or postdictability, present for interest to occur. That is, according to Kintsch's postdictability hypothesis, it is not the disruption of the schema that leads to interest, but rather it is the potential integration, or assimilation of the unexpected information through some resolution, that affects interest. The postdictability hypothesis thus predicts that unexpectedness will lead to high interest only when it is at an intermediate amount, where some disruption occurs but postdictability is obtainable. For situations of low unexpectedness, when no disruption occurs, and high unexpectedness, when disruption occurs but postdictability is not attainable, this hypothesis predicts that interest in the information will be low. This hypothesis clearly maps onto the KST. Without postdiction, an unexpected event only disrupts a schema, but does not enhance or modify the schema; postdictability allows for the unexpected information to be eventually assimilated into the current knowledge structures, or to modify the pre-existing schema, and thus is necessary to increase interest. Two experiments by Iran-Nejad (1987) provided evidence that postdictability was indeed necessary for making unexpected information interesting. Iran-Nejad had subjects read stories that varied in both degree of the surprise of their ending and their degree of resolution. His findings support Kintsch's (1980) hypothesis: only in the resolved condition, where the surprise endings of the stories were sufficiently resolved to allow for postdiction, were the high-surprise stories rated as significantly more interesting than the low-surprise stories.

Frick (1992) also posits that unexpectedness is not sufficient to cause interest, but must be paired with the possibility of change in a belief. According to Frick's changing beliefs hypothesis, the degree of unexpectedness is not predictive of the amount of interest unless the unexpectedness causes one to change their beliefs or confidence in their beliefs. This hypothesis conforms to the predictions of the KST. As stated above, the KST does not predict that unexpected information will be sufficiently to increase interest; however, when the unexpected information leads to a modification of one's knowledge (i.e., changes a belief), interest should result.

Frick (1992) tested this hypothesis by assigning subjects to two conditions, either coin-flipping or coin-spinning. Subjects in both groups expect both tasks to be unbiased, that is, the probability of getting heads or tails are equal (P = .50) for both flipping and spinning. In fact, in reality coin-spinning results in a greater probability of getting a tails result (P = .80) than a heads result (P = .20). Thus, Frick predicted that subjects in the coin-spinning group, who would have to change their beliefs about the probability of getting a certain outcome, would report higher interest in the task than those in the coin-flipping group, whose expected probabilities were consistent with the observed outcomes. His hypothesis was supported by his findings, in that the average interest in the coin-spinning group was significantly greater than that in the coin-flipping group. A notable trend in subjects' trial-by-trial report for the coin-spinning group lends further support for this hypothesis. Interest ratings rise steadily for this group, peaking at about thirteenth trial (there were 25 trials in all), after which interest ratings slowly decline. Verbal protocols indicate that until this point, subjects maintained their belief in the equal probability of a heads or tail outcome. Their interest rose as the evidence became increasingly inconsistent with their belief. However, sometime around the thirteenth trial, subjects changed their beliefs, in that they now expected a greater number of tails than heads, and thus further evidence, which was now consistent with their new belief, elicited less and less interest. In the terms of the KST, interest rose as evidence inconsistent with one's schemas increased, reached a peak when the schema was modified to incorporate this information, and then decreased as the incoming information was now redundant with their knowledge-structures, no longer eliciting significant schema elaboration or change.

According to Frick's (1992) changing beliefs hypothesis, then, interest should increase when an outcome leads to a change in one's belief about an event, which, as described above, is consistent with the knowledge-schema theory of cognitive interest, in that a change in belief is analogous to schema modification, one of the conditions the KST states as producing interest. However, Frick also wrote that "an outcome expected with the fullest confidence would provide no reason to change beliefs, and hence would be uninteresting" (Frick, 1992, p. 120). This corollary to Frick's hypothesis is inconsistent with the KST, in that the KST predicts interest can also be produced by schema elaboration, in which a previously held belief is maintained, and one's confidence in the validity of that belief is not necessarily changed.

While schema enhancement can often involve changes in confidence (e.g., getting new, supporting information can often lead to increasing confidence in a belief), it is not a necessary condition. For example, a person's confidence that gravity keeps them from floating away from the earth is no doubt extremely high, yet they may find it quite interesting to know exactly why and how gravity works, despite the fact that their belief and confidence in this belief that these laws are true will not change (i.e., they are already at a ceiling level). In a more general sense, the KST predicts that receiving explanatory information about an outcome, such as the underlying mechanisms that produce the outcome, will be interesting regardless of whether it changes one's confidence or beliefs, if this information leads to schematic enhancement.

The two experiments described in this paper seek to show that interest will vary both as a function of schematic change, when given information about an expected or unexpected outcome as in Frick (1992), as well as schematic enhancement, when given information that is informative (e.g., information that is explanatory of an outcome) or uninformative (e.g., information that is descriptive of an outcome). Frick's (1992) changing beliefs hypothesis predicts that only unexpected outcomes will lead to increases in interest, and that the type of information given about the outcome, whether explanatory or descriptive, should have no effect on interest. The KST, however, predicts that both the expectedness of the outcome and the type of information given about the outcome should affect subsequent interest. The current experiments test whether both conditions, as specified by the KST, influence interest.

In both experiments, the expectedness of outcomes will be manipulated as in Frick (1992), with participants learning about the probability of getting a 'heads' outcome when a coin is flipped (expected) or spun (unexpected); however, unlike Frick's participants, participants in the current experiments will learn about these outcomes from reading a passage, rather than by actually flipping or spinning coins. The type of information participants receive about the respective outcomes will be either explanatory or descriptive. Participants in the explanatory condition will receive <u>mechanism</u> information about the outcome, which discusses the physical features of a United States penny that explain the reasons why a flipped coin will lead to a 'heads' outcome 50% of the time, or why a spun penny will lead to a 'heads' outcome 20% of the time. Participants in the descriptive condition will receive <u>frequency</u> information about the outcome, which describes a number of trials of coin flipping that led to a 'heads' outcome half of the time, or trials in which spun penny led to a heads outcome 20% of the time. The KST predicts two effects: that passages describing an unexpected outcome (i.e., coin spins) will be rated as more interesting than those containing an expected outcome (i.e., coin flips), since only the former passages will induce schema modification; and that passages containing explanatory (i.e., mechanism) information will be rated as more interesting than those containing descriptive (i.e., frequency) information, since only the former passages will induce schema enhancement.

Experiment 1

Method

<u>Participants</u>

One hundred fifty-two undergraduates at the University of California, Los Angeles, participated in this experiment to receive course credit. One hundred seventeen participants were enrolled in an introductory psychology class, and thirty-five were enrolled in an introductory cognitive psychology class. Participant source had no direct effect on learning and interest, nor did it interact with either of the manipulated factors, so all participants were collapsed into one group, regardless of source, for the data analyses.

Design

A 2 x 2 between-participants design was used. The first factor was expectedness of outcome, with the two levels being an expected outcome (coin flip) and the second being an unexpected outcome (coin spin). The second factor was information type, with half of the participants receiving descriptive (frequency) information about the outcome, and the other half receiving explanatory (mechanism) information about the outcome. Two dependent variables were measured. The first dependent measure was a judgment of perceived learning from the passage, as indicated on a 7-point Likert scale. This measure of perceived learning was not given to the first 59 participants, and therefore all analyses involving learning will include data for only the last 93 participants. The second dependent measure was a rating of interest for the passage, also recorded on a 7-point Likert scale.

Materials and procedure

Participants were randomly assigned to one of the four conditions described above. All participants received a 4-page packet appropriate to their condition. On the first page of the packet, participants were asked to predict the percentage of the time a U.S. penny will land with 'heads' up when flipped into the air (in the expected outcome condition) or spun on a flat surface (in the unexpected outcome condition), and to indicate their confidence in their belief on a 7-point Likert scale. On the second page of the packet was a short passage (ranging between 51 and 64 words) corresponding to the participant's condition. In the expected outcome/frequency information condition, participants read about a computer program that encoded the physical dimensions of an actual, unbiased U.S. penny simulated 10,000 flips, leading to approximately 50% 'heads' outcomes. In the unexpected outcome/frequency information condition, participants read that a computer program that encoded the physical dimensions of an actual, unbiased U.S.

penny simulated 10,000 spins, leading to approximately 20% 'heads' outcomes. In the expected outcome/mechanism information condition, the passage contained information about the physical features of a coin that explain why a flipped coin leads to a 'heads' outcome 50% of the time, while in the unexpected outcome/mechanism information condition, the passage contained information about the physical features of a coin that explain why a spun coin leads to a 'heads' outcome 20% of the time. A sample passage, which was read by participants in the unexpected outcome/mechanism condition follows:

> While the weights of both sides of a U.S. penny are equal across the entire face, one edge of the penny is thinner than the other. At the thinner edge, the weight on the 'heads' side is lighter than that on the 'tails' side. Therefore, the probability of a penny landing with a 'heads' outcome after spinning is approximately 20%.

The four passages used in this experiment are presented in Appendix A.

On the third page of the packet, participants were asked to rate how interesting they found the passage on a 7-point Likert scale, with higher scores indicating higher perceived interest. On the fourth page of the packet, participants' predictions about the outcome were again assessed, by repeating the question "What percentage of the time do you predict a U.S. penny will land with 'heads' up when flipped into the air [spun on a flat surface]?". A measure of perceived learning was then given for the last 93 participants. These participants were asked to indicate the amount of new information they believed they learned on a 7-point Likert scale, with higher scores indicating a greater amount of perceived learning. Participants were then asked to justify this judgment by writing down what they had learned from the passage, or, if indicating they had learned nothing from the passage (i.e., a score of "1"), where they had encountered the information prior to the experiment.

Analysis strategy and expected results

A number of statistical techniques were used to assess how well the data fit the predictions of the KST. First, an analysis of learning will be conducted, using an analysis of variance (ANOVA) to test if perceived learning varied appropriately as a function of condition. It is expected that the amount of perceived learning will be higher for participants who read passages containing unexpected outcomes than for those who read passages containing expected outcomes, since only the former should induce schema change. It is also predicted that perceived learning will be greater for those reading passages containing explanatory (mechanism) information than for those reading passages containing descriptive (frequency) information, since only the former should induce schema elaboration.

A second ANOVA will be performed to test the effects of the manipulated factors on perceived interest for the passage. The pattern of results for interest ratings is expected to mirror those of learning, with interest rated higher for passages containing unexpected outcomes and mechanism information than for those containing expected outcomes or frequency information. Given that the same patterns for learning and interest as functions of the two factors are expected, it follows that there should be a direct covariance between perceived learning and interest, and therefore the correlation between these two measures was tested.

As discussed above, Frick (1992) claims that interest will be low for information that does not either change a belief or confidence in a belief. The KST, however, predicts that interest can be induced in the absence of these conditions if a schema is enhanced. Confidence ratings from both before and after the passage are compared for the participants in the mechanism/expected condition to measure if the proposed schema enhancement in fact changed participants' confidence about the outcome of a coin flip. If a change occurred, then the two opposing theoretical claims are not at odds; however, if confidence does not change for these participants, then the two theories are distinguishable in their predictions. Specifically, if confidence for the mechanism/expected group does not change, as assessed using a paired-samples t-test, the changing beliefs hypothesis would expect no difference in interest ratings between this group and those in the frequency/expected group, whereas the KST predicts that, given the former group experiences schema enhancement while the latter group does not, the mechanism/expected condition should have higher interest ratings for the passage than those in the frequency/expected condition. Given that there is no change in confidence for the mechanism/expected group, an independent samples t-test will be used to determine if a significant difference exists on interest.

Finally, covariance matrix modeling techniques using a maximum likelihood estimation procedure were used to assess the relations among the two manipulated factors, learning, and interest that are proposed by the KST. The KST predicts that expectedness and information type will only have an indirect effect on interest, such that the relation between these factors and interest is mediated by learning (see Figure 1, Model A). In addition to testing how well this proposed model fits the data, two alternative models were tested. The first alternative model proposes the opposite causal relation between learning and interest, such that in this model, the relation between the two factors and learning is mediated by interest (see Figure 1, Model B). This alternate model is driven by the oft-tested hypothesis (e.g., Alexander, Kulikowich, & Schulze, 1994; Anderson, Shirey, Wilson, & Fielding, 1984; Garner & Gillingham, 1991; Wade & Adams, 1990) that learning is an outcome, rather than a predictor, of interest. Comparing these two models will provide evidence for establishing the causal direction between learning and interest. Finally, a third model, in which learning and interest are posited to be independently caused by interest, was examined (see Figure 1, Model C). This model proposes a type of null hypothesis, that interest and learning are not causally related.

It is expected that the first model (model A), which exemplifies the relation among learning and interest as predicted by the KST, provides a better fit of the data than the two alternative models. Both a chi-square test and comparative fit indices (CFI) were used as measures of the goodness-of-fit for each model. A non-significant chi-square indicates that the covariational pattern in the data is not significantly different from that represented in the proposed model, but is often unduly affected by a small sample size. The CFI is an index of model fit that is robust to smaller sample sizes (Bentler, 1990), with a CFI of .90 (with the maximum value being 1.0) generally considered the minimum value for which the model can be considered an adequate fit of the data.

Results

As will be explained in more detail in the discussion section below, some participants did not change or maintain their belief in the way that was appropriate to the experimental manipulation. While few participants in the expected outcome condition changed their belief after reading the passage (and for those who did, most changed it from a non-50% response to a 50% response), a great number of participants in the unexpected outcome condition failed to change their belief. The data from these participants were not included in the analysis of group differences in perceived learning or interest, as the manipulation was not effective for these participants. However, data from these participants were included in the correlational and covariation structure analyses, where the relation between learning and interest independent of condition were of statistical interest.

Descriptive Statistics

Across all conditions, participants tended to find the passages moderately interesting (M = 4.28, SD = 1.55), and perceived themselves as learning a moderate amount from the passages (M = 4.03, SD = 1.89). Both distributions were approximately normal.

Perceived learning

The predicted differences in perceived learning due to expectedness of outcome and information type were supported by the data. A two-factor analysis of variance (ANOVA) showed main effects for both expectedness of outcome, with learning perceived as higher for passages with unexpected outcomes (M = 5.58, SD = 1.22) than expected outcomes (M = 3.18, SD = 1.60), $F(1, 59) = 24.46$, $p < .001$, and information type, with learning rated higher for passages containing mechanism information (M = 4.62, SD = 1.74) than for those containing frequency information (M = 2.75, SD = 1.42), $F(1, 59) = 11.79$, $p < .002$. There was no interaction between the two factors on learning, $F(1, 59) < 1$. The cell means for perceived learning across all four conditions can be seen in Figure 2.

Perceived interest

It was found that unexpected outcomes and mechanism information were rated significantly more interesting than expected outcomes and frequency information. A two-factor ANOVA showed main effects for both expectedness of outcome, with interest rated higher for the unexpected outcomes ($M = 5.35$, $SD = 1.10$) than expected outcomes ($M = 3.53$, $SD = 1.42$), $F(1, 109) = 40.01$, $p < .001$, and information type, with interest rated higher for mechanism information ($M = 4.61$, $SD = 1.48$) than for frequency information ($M = 3.54$, $SD = 1.52$), $F(1, 109) = 7.37$, $p < .01$. There was no interaction between the two factors on interest, $F(1, 109) < 1$. The cell means for interest across the four conditions can be seen in Figure 3.

Confidence ratings and comparison of the two expected outcome conditions

A paired-samples t-test found that participants in the mechanism/expected did not significantly change their confidence about the percentage of time a coin would land on 'heads' when flipped; pre-passage confidence ($M = 6.33$, $SD = 0.83$) was not significantly different from post-passage confidence ($M = 6.33$, $SD = 0.83$), $t(35) = 1.87$, $p > .05$, two-tailed. Given this result, an independent-samples t-test was used to assess if there was a difference between the interest ratings by the mechanism/expected group and the frequency/expected group. Interest ratings for those in the mechanism/expected condition ($M = 3.92$, $SD = 1.40$) were indeed significantly greater than for participants in the frequency/expected condition ($M = 3.14$, $SD = 1.36$), $t(71) = 2.42$, $p < .02$.

Correlation between learning and interest

Given that both perceived learning and interest had similar patterns as a function of the two manipulated factors, it would be expected that they will directly covary, as predicted by the KST. Indeed that is the case, as a significant positive correlation was observed between the two measures, $r = .52$, $p < .001$, two-tailed.

Covariation matrix modeling

A covariational structure analysis was used to test whether the proposed causal model of the relation between learning and interest provides an adequate fit of the data, and a better fit than alternative models. Again, as shown in Figure 1, three plausible models were tested. Model A is the model proposed by the KST, with learning predicting interest. Model B captures the opposite causal direction, with interest predicting learning. Finally, model C posits learning and interest as unrelated.

For the KST proposed model (model A), in which learning predicts interest, the covariational analysis revealed a significant chi-square, _^{2}(3, N = 93) = 8.293, p = .04, but had a CFI value of .909, indicating that this model provided an adequate fit of the data. For the causally reversed model (model B), in which interest predicts learning, the analysis revealed a significant chi-square, _^{2}(3, N = 93) = 14.661, p = .002, with a CFI value of .799, indicating that this model provides a poor fit of the data. Finally, for model C, in which learning and interest are predicted to be unrelated, the analysis again revealed a significant chi-square, _^{2}(3, N = 93) = 16.73, p < .001, and a CFI value of .746, indicating that this model also fits the data poorly (as would be expected given the significant correlation between learning and interest reported above). The standardized parameter estimates for each of the three models can be found in Figure 4[2].

Discussion

The results support the prediction of the knowledge-schema theory of interest that the amount of learning induced by the passages predicts perceived interestingness. Both perceived learning and interest followed the same pattern as a function of outcome type and information type, indicating that they are affected similarly by schema elaboration and change. In addition, a test of the explanatory power of several possible models indicates that the proposed model provided the best, and only adequate, fit of the data. The evidence from study 1, then, supports the predictions of the knowledge-schema theory of cognitive interest that the amount of learning a passage induces, either through schema modification or schema enhancement, directly affects the degree of interest for the passage.

Frick's (1992) belief change hypothesis and the KST both expect that there will be high interest for information that induced a belief change, or schema modification. Only the KST, however, predicts a difference due to type of information (i.e., mechanism) for passages

[2]Standardized parameter estimates are analogous to standardized beta weights in a regression analysis.

containing expected outcomes, given that participants' confidence did not change in the mechanism/expected condition. This study thus provides evidence that schema enhancement is also a predictor of interest.

Only 27.8% of all participants (10 of 36) in the unexpected outcome/frequency information condition changed their beliefs[3]. This limits both the reliability of statistical inferences (due to there being only 10 participants in this cell), as well as the generalizability of the results. Participants who did experience schematic change in this condition might perceive a passage's interestingness differently than those who did not. Because of this problem, new passages were created and a second experiment was run.

Experiment 2

The design and procedures of experiment 2 replicated those of the previous experiment, with the only difference being the content of the passages. While the passages were about the same general subject (i.e., outcomes of coin flips and spins), a number of facts were introduced to make the passages more credible to participants in an effort to eliminate the problem experienced in experiment 1, of participants not maintaining or changing their beliefs about the outcome appropriate to their condition. New additions to the passages included: increasing the number of times each experiment (i.e., flipping or spinning the coin, or physically examining the coin) was conducted from one to five; citing names and years for these experiments and giving the name of an academic journal in which they were (fictionally) published; claiming that 10,000 flips or spins is a sufficient number to eliminate random error; and stating that all experimentation was done by humans rather than by computer simulation (as in the previous frequency passages) or no attributed source (as in the previous mechanism passages). A pilot study indicated that the newer passages (particularly for the frequency/unexpected condition) maintained or changed

[3]The percentages of participants in the other conditions for whom belief change was appropriate for the condition were 92.3% (36/39) for frequency/expected, 94.9% (37/39) for mechanism/expected, and 78.9% (30/38) for mechanism/unexpected.

participants' beliefs more appropriate to their condition than those passages used in the previous experiment[4].

Method

Participants

Two hundred six undergraduates in an introductory psychology course at the University of California, Los Angeles, participated in this experiment to receive course credit.

Design

The experimental design in the current experiment paralleled that of experiment 1. Again, a 2 x 2 between-participants design was used, with the first factor being expectedness of outcome (either expected [coin flip] or unexpected [coin spin]) and the second factor being information type (either descriptive [frequency] or explanatory [mechanism] information). The same two dependent variables, perceived learning and interest, were measured, again both on 7-point Likert scales.

Materials and procedure

The materials and procedure of this experiment were identical to those in experiment 1, save the differences in passage content as described above. Given the new information added to increase credibility, the current passages (see Appendix B) were longer than those in experiment 1, ranging from 88 to 106 words.

As in experiment 1, all participants received a 4 page packet, which assessed their belief before and after reading the passage, as well as their interest and perceived learning ratings. The learning measure used was identical to that used in the previous experiment.

Analysis strategy and expected results

The data will be analyzed in the same manner as in experiment 1: effects of the two conditions on both learning and interest will be tested using two ANOVA procedures, the

[4]The pilot study of the effectiveness of various factors in leading to belief change showed that using a computer simulation as evidence was the largest obstacle to changing belief in the unexpected outcome conditions. Interviews with participants revealed that they most often attributed the unexpected finding to a 'bug' in the computer simulation. Gorsky and Finegold (1994) reported a similar observation in their study of conceptual change using data from computer simulations.

correlation between learning and interest will be tested, and covariance matrix modeling techniques will be used to asses the efficacy of the three proposed theoretical models (Figure 1) in explaining the data. Also, differences in belief confidence before and after the passage will again be tested for the mechanism/expected condition to allow for a comparison of this group with the frequency/expected group to test the discrepancy between the changing beliefs hypothesis and the KST.

The same results expected in experiment 1 are expected here; that is, both learning and interest are predicted to be judged higher for participants reading passages containing unexpected outcomes and mechanism information than for those reading passages containing expected outcomes and frequency information, learning and interest are expected to directly covary, and it is also expected that the structural model that captures the causal relation between learning and interest as specified by the KST will provide a good fit of the data, and a better fit than that by the alternative models.

Results

Effectiveness of passage changes on belief change or maintenance

The changes made to improve passage credibility proved effective. The percentage of participants who changed their belief increased in both of the unexpected conditions, to 86% (43/50; from 78.9% in experiment 1) for the mechanism/unexpected condition, and, most critically, to 73.1% (38/52; from 27.8% in experiment 1) for the frequency/unexpected condition.[5] While the effect of condition on belief change was still less than perfect, the number and percentage of participants who changed beliefs in this condition are sufficient for both theoretical and statistical interpretations.

Descriptive Statistics

Across all conditions, participants again rated the passages as moderately interesting ($\underline{M}$ = 4.54, $\underline{SD}$ = 1.43), and again perceived themselves as learning a moderate amount from the

[5]The percentage of participants in the expected outcome conditions for whom belief change was appropriate remained virtually identical to those in experiment 1, 92.3% (48/52) and 94.2% (49/52) for the frequency/expected and mechanism/expected conditions, respectively.

passages ($\underline{M}$ = 4.59, $\underline{SD}$ = 1.82). Both interest and learning ratings are slightly higher in the current experiment than in experiment 1, most likely due to the longer and more involved passages implemented in this second experiment. Both distributions were approximately normal.

Perceived learning

A 2 x 2 ANOVA yielded significant main effects on perceived learning due to both expectedness of outcome, with perceived learning greater for unexpected outcomes ($\underline{M}$ = 5.51, $\underline{SD}$ = 1.37) than expected outcomes ($\underline{M}$ = 3.85, $\underline{SD}$ = 1.84), $\underline{F}(1,174) = 54.37$, $p < .001$, and type of information, with perceived learning greater for passages containing mechanism information ($\underline{M}$ = 5.27, $\underline{SD}$ = 1.44) than for those containing frequency information ($\underline{M}$ = 3.88, $\underline{SD}$ = 1.95), $\underline{F}(1,174) = 37.53$, $p < .001$. These main effects cannot be interpreted in a straight-forward manner, however, as the analysis also yielded a significant interaction between expectedness of outcome and information type on perceived learning, $\underline{F}(1, 174) = 10.74$, $p < .002$. A post-hoc Tukey test (_ = .05) was used to contrast the cell means (which are presented in Figure 5), and revealed that perceived learning was equivalent for both of the unexpected outcome groups (with means of 5.77 for the mechanism/unexpected condition and 5.21 for the frequency/unexpected condition), that learning for the mechanism/expected condition ($\underline{M}$ = 4.84) was significantly lower than for the mechanism/unexpected condition, and that learning in the frequency/expected condition ($\underline{M}$ = 2.83) was significantly lower than for each of the other three conditions.

Perceived interest

A similar pattern as with learning was found for perceived interest as a function of both factors. Again, a 2 x 2 ANOVA yielded significant main effects on interest for both expectedness of outcome, with interest rated higher for passages with unexpected outcomes ($\underline{M}$ = 4.98, $\underline{SD}$ = 1.24) than expected outcomes ($\underline{M}$ = 4.18, $\underline{SD}$ = 1.44), $\underline{F}(1,174) = 15.98$, $p < .001$, and type of information, with perceived learning greater for passages containing mechanism information ($\underline{M}$ = 4.80, $\underline{SD}$ = 1.26) than for those containing frequency information($\underline{M}$ = 4.26, $\underline{SD}$ = 1.51), $\underline{F}(1,174) = 7.26$, $p < .01$. As before, the main effects cannot be directly interpreted, for again here a significant interaction occurred between the two factors, $\underline{F}(1,174) = 8.44$, p <

.01. A post-hoc Tukey test (_ = .05) was again used to contrast the cell means (shown in Figure 6), which showed that interest for the passage was not significantly different among participants in the mechanism/expected condition ($\underline{M}$ = 4.69), the mechanism/unexpected condition ($\underline{M}$ = 4.93), and the frequency/unexpected condition ($\underline{M}$ = 5.03), but was significantly lower than for these three conditions for those in the frequency/expected condition ($\underline{M}$ = 3.65).

Confidence ratings and comparison of the two expected outcome conditions

Contrary to what was found in the first experiment, a paired-samples t-test found that participants in the mechanism/expected significantly increased in their confidence about their belief regarding the results of coin flipping; post-passage confidence ($\underline{M}$ = 6.57, $\underline{SD}$ = 0.65) was significantly greater than pre-passage confidence ($\underline{M}$ = 6.19, $\underline{SD}$ = 0.85), $\underline{t}(46) = 3.88$, $p < .001$, two-tailed. Given this difference, the predictions of the changing beliefs hypothesis cannot be falsified. As stated above in the description of the cell means, however, participants in the mechanism/expected condition did again rate the passage as more interesting than those in the frequency/expected condition.

Correlation between learning and interest

As in experiment 1, both perceived learning and interest had similar patterns as a function of the two manipulated factors, so again it is expected that they will directly covary, as predicted by the KST. This prediction is confirmed by the observed positive correlation between the two measures, $\underline{r} = .45$, $\underline{p} < .001$, two-tailed.

Covariation matrix modeling

A covariational structure analysis was again used to test how well the three proposed theoretical models of the relation between learning and interest approximated the observed patterns of the data. The analysis of model A, which supports the predictions of the KST that learning predicts interest, was again found to be an excellent fit of the data, yielding a non-significant Chi-square, $\_^2(3, \underline{N} = 206) = 3.433$, $\underline{p} > .3$, and a CFI value of .995. Model B, which proposes the opposite causal relation, that interest predicts learning, was again a poor fit of the data, as evidenced by a significant Chi-square, $\_^2(3, \underline{N} = 206) = 44.267$, $\underline{p} < .001$, and a CFI value of .545. Model C, which theorizes that learning and interest are independent functions of the two manipulated factors, also failed to provide an adequate fit of the data, with a significant Chi-square, _^{2}(2, N = 206) = 18.850, p < .001, and a CFI value of .814. Thus, as in experiment 1, the model reflecting the predictions of the KST provides a much better fit of the data than the two alternative models. The three models, with standardized path estimates, are presented in Figure 7.

Discussion

The results from experiment 2 generally support the predictions of the KST. Interest was higher for the passages that induced learning through either schema enhancement (i.e., mechanism passages) or schema modification (i.e., passages with unexpected outcomes) than for the passage inducing neither. It is clear from these results, then, that the KST correctly predicts that inducing either schema modification or schema enhancement is a sufficient condition for an environment to elicit interest.

The effects of the factors on both perceived learning and interest were not exactly as predicted, specifically in that perceived learning and interest did not increase stepwise with added schema enhancement or modification (as in experiment 1). However, the patterns of both were parallel as a function of condition, which is reflected in the high, positive correlation observed between the two measures. In addition, the covariance matrix modeling techniques again strongly favor the proposed relation between learning and interest as specified by the KST over two plausible alternative models.

General Discussion

Both experiments presented in this paper provide evidence for the predictions of the knowledge-schema theory of cognitive interest regarding the direct effect of learning on interest. Across both experiments, interest varied in the expected direction as a function of both expectedness of outcomes and type of information. Interest was higher for passages containing unexpected outcomes than for those containing expected outcomes; the KST predicted this result by assuming that unexpected outcomes would produce learning through schema change, a condition the KST specifies as leading to higher interest. The fact that perceived learning was higher for the passages containing unexpected outcomes buttresses this assumption. These findings are consistent as well with Frick's (1992) changing beliefs hypothesis, in that passages that modified one's belief did increase interest.

Whereas Frick (1992) holds that changing a belief or confidence in a belief is necessary to increase interest, the KST holds that schema modification is a sufficient predictor of interest. The KST also predicts that interest will be high when a schema is elaborated by information, even while the schema maintains its basic structure. The results from both experiments support this second hypothesis of the KST, in that interest was high for passages that described the outcome using mechanistic, but not frequency, information. Perceived learning was greater for the mechanism passages than frequency passages, indicating that learning was induced by elaborating participants' schemas regarding the explanatory causes of an outcome. In addition, Frick's claim regarding the necessity of confidence change in the absence of belief change to increase interest, which is in opposition to the predictions of the KST, was tested directly in experiment 1, with results contrary to the changing beliefs hypothesis and consistent with the KST.

While the patterns of learning and interest as a function of expectedness of outcome and information type varied across experiments, within each experiment these patterns were the same. That is, in both experiments, passages that induced higher amounts of perceived learning were rated as interesting, and passages that induced lower amounts of perceived learning were rated as significantly less interesting. This relation is also indicated by the reliable positive covariance observed between learning and interest in both experiments.

In addition to affirming the prediction that learning and interest would covary as a function of the manipulated factors, covariance matrix modeling techniques allowed the testing of the causal direction between learning and interest. According to the KST, learning is a predictor of interest. Therefore the causal direction should go from learning to interest, rather than the other way around[6]. Across both experiments, this causal model proposed by the KST provided a good fit of the data, and a better fit than two competing theoretical and statistical models.

This set of experiments, then, provides good support for the hypotheses that stem from the KST, that degree of learning resulting from either schema enhancement or modification predicts the degree of interest for an informational environment. However, there are some limitations within these two studies. First, the scores of learning were taken from a self-report measure, rather than a quantitative demonstration of learning. Research has shown (e.g., Glenberg, Wilkinson, & Epstein, 1982) that what one thinks they have learned does not directly correspond to what one has actually learned; thus, perceived learning is not an optimal indicator of true learning. To increase the validity of learning measures, further experiments of the KST use demonstrations of learning (e.g., improvement from a pre-passage to post-passage knowledge test) rather than self-reports.

A second limitation is that the passages used in these experiments were quite short and only dealt with a single, simple concept, either coin flipping or coin spinning. Passages used in real-world contexts (e.g., a school setting) are generally longer and more complex. The amount of learning from these passages, then, is quite relative; the amount of schema modification or enhancement induced by the passages was low relative to the amounts induced by passages dealing with more and more complex information. Still, participants seemed to take this relativism into account when reporting amount of perceived learning; when comparing the amount of learning from this short passage to the amount learned in a classroom over the course of a year, it would be expected that all participants would rate the amount of knowledge gained from these passages as extremely low. Given that perceived learning did vary as a function of condition is an indication that participants had a tacit understanding that the comparison of their

[6]The KST does not claim, however, that only one of these views can be correct at any one time. Results from many studies, as outlined above, show that increases in interest can have powerful effects on future learning. Rather, the KST states that learning is the primary, or first, cause of interest, rather than interest being the first cause of learning. The author will discuss later in the paper how the two processes (i.e., learning increasing interest, and interest increasing learning) can work together to create an increasing spiral effect that ultimately maximizes both learning and interest.

learning from the passage would be relative to the amount of learning that might occur due to another passage of similar length.

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Appendix A

Target passages used in experiment 1

Expected-frequency

A computer was programmed to simulate a coin flip and record the outcome (heads or tails). The physical dimensions of an actual U.S. penny were encoded into the program. After simulating 10,000 flips, the computer reported 4963 'heads' results; that is, 49.63% of the simulated flips resulted in a 'heads' outcome.

Unexpected-frequency

A computer was programmed to simulate a coin spin and record the outcome (heads or tails). The physical dimensions of an actual U.S. penny were encoded into the program. After simulating 10,000 spins, the computer reported 1963 'heads' results; that is, 19.63% of the simulated spins resulted in a 'heads' outcome.

Expected-mechanism

The weights of both sides of a U.S. penny differ at various points along the face, with both the 'heads' and 'tails' sides being light at one end and heavier at the other. However, the weights of both sides of a penny are equal across the entire face. Therefore, the probability of a penny landing with a 'heads' outcome after flipping is approximately 50%.

Unexpected-mechanism

While the weights of both sides of a U.S. penny are equal across the entire face, one edge of the penny is thinner than the other. At the thinner edge, the weight on the 'heads' side is lighter than that on the 'tails' side. Therefore, the probability of a penny landing with a 'heads' outcome after spinning is approximately 20%.

Appendix B

Target passages used in experiment 2

Expected-frequency

Five independent studies, by Brown and Shifman (1993), Toms (1993), Kelsey and Overmeir (1994), Duncan (1995), and Sandhill (1995), have recently been published in the Journal of Probabilistic Studies. In each of these independent experiments, the experimenters, as well as their student advisees, flipped actual U.S. pennies and recorded the outcome (heads or tails). Each experiment recorded results from 10,000 flips, which is a sufficient number to eliminate random error. Each set of researchers independently found that approximately 50% of the coin flips resulted in a 'heads' outcome.

Unexpected-frequency

Five independent studies, by Brown and Shifman (1993), Toms (1993), Kelsey and Overmeir (1994), Duncan (1995), and Sandhill (1995), have recently been published in the Journal of Probabilistic Studies. In each of these independent experiments, the experimenters, as well as their student advisees, spun actual U.S. pennies on flat surfaces and recorded the outcome (heads or tails). Each experiment recorded results from 10,000 spins, which is a sufficient number to eliminate random error. Each set of researchers independently found that approximately 20% of the coin spins resulted in a 'heads' outcome.

Expected-mechanism

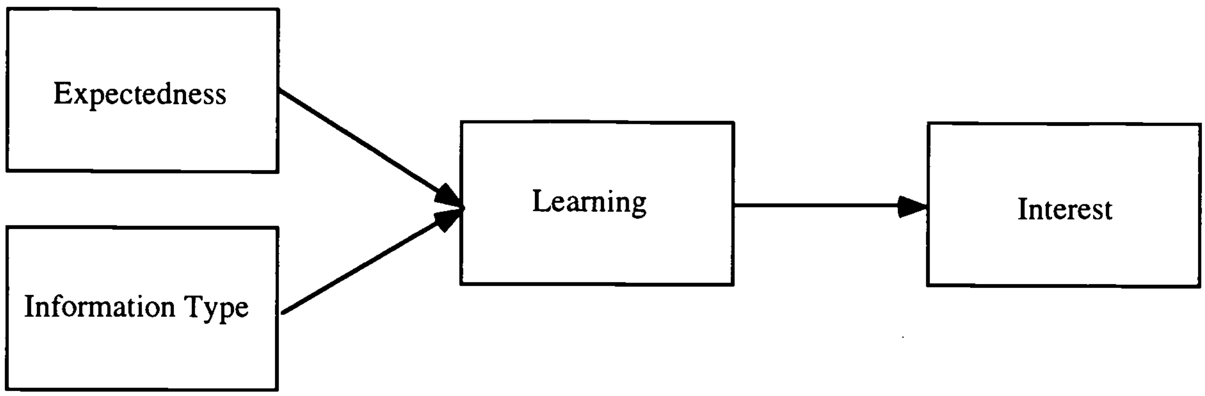
Five independent studies, by Brown and Shifman (1993), Toms (1993), Kelsey and Overmeir (1994), Duncan (1995), and Sandhill (1995), have recently been published in the Journal of Material Science. These experimenters independently studied the physical dimensions of actual U.S. pennies. Each set of experimenters found that the weights of both sides of a penny differ at various points along the face. Both the 'heads' and 'tails' sides are lighter at one end and heavier at the other, with the weights of both sides being equal across the entire face. Therefore, the probability of a penny landing with a 'heads' outcome after flipping is approximately 50%.

Unexpected-mechanism

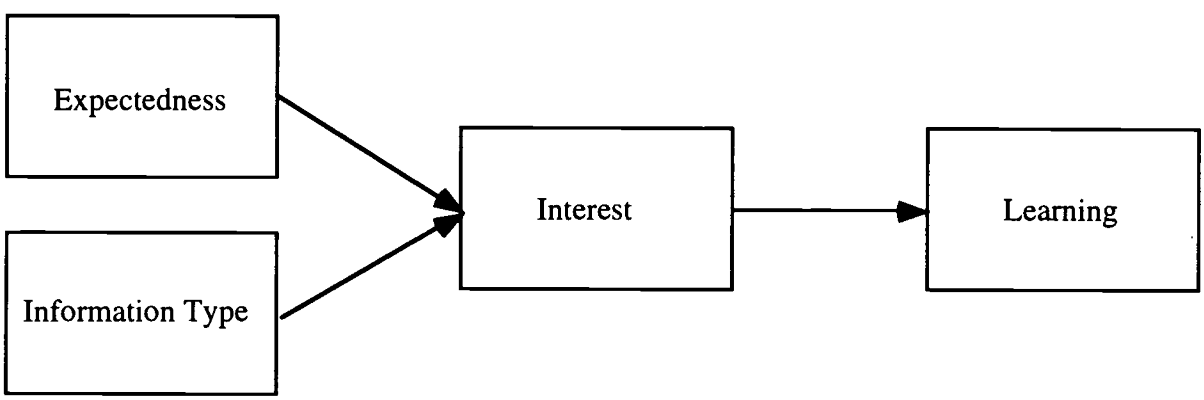
Five independent studies, by Brown and Shifman (1993), Toms (1993), Kelsey and Overmeir (1994), Duncan (1995), and Sandhill (1995), have recently been published in the Journal of Material Science. These experimenters independently studied the physical dimensions of actual U.S. pennies. Each set of experimenters found that the weights of both sides of a penny are equal across the entire face, and that one edge of the penny is thinner than the other. At the thinner edge, the weight on the 'heads' side is heavier than that on the 'tails' side. Therefore, the probability of a penny landing with a 'heads' outcome after spinning is approximately 20%.

Figure 1: Three proposed covariation structural models in Experiments 1 and 2

Model A



Model B



Model C

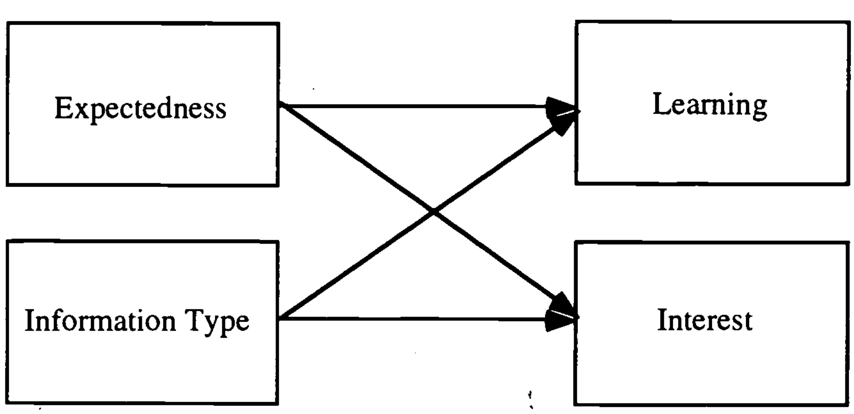


Figure 2: Amount of perceived learning from the target passage as a function of expectedness of outcome and type of information in experiment 1.

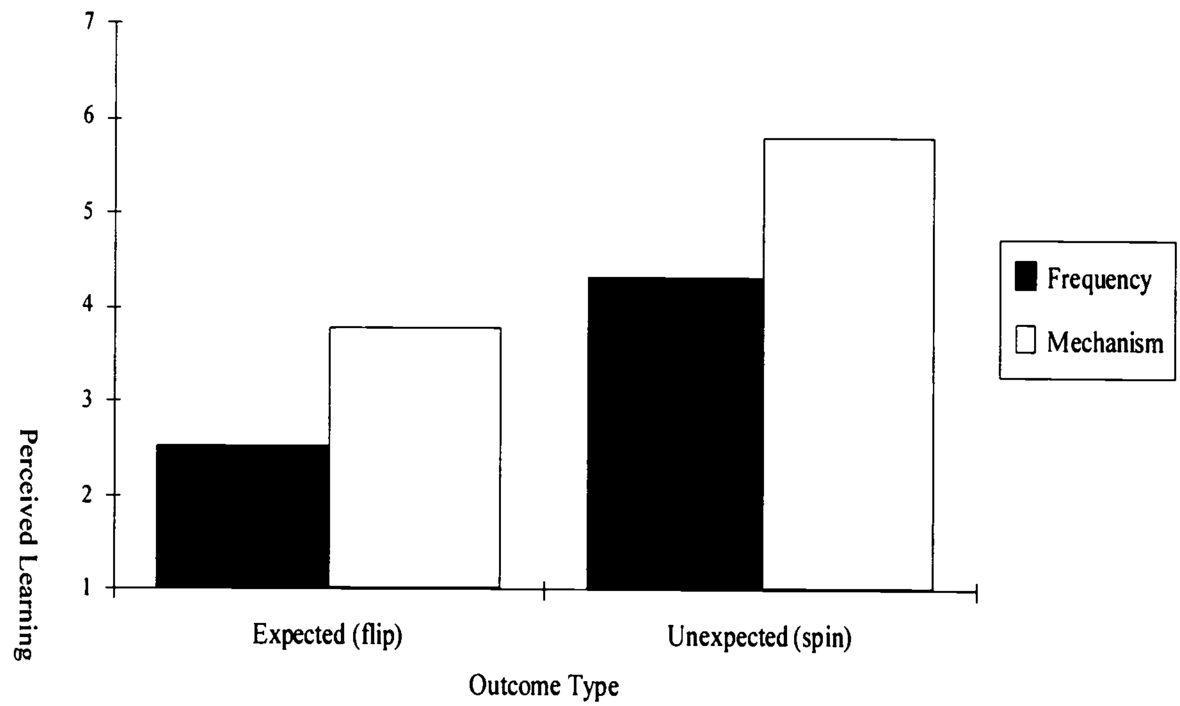


Figure 3: Amount of perceived interest for the target passage as a function of expectedness of outcome and type of information in experiment 1.

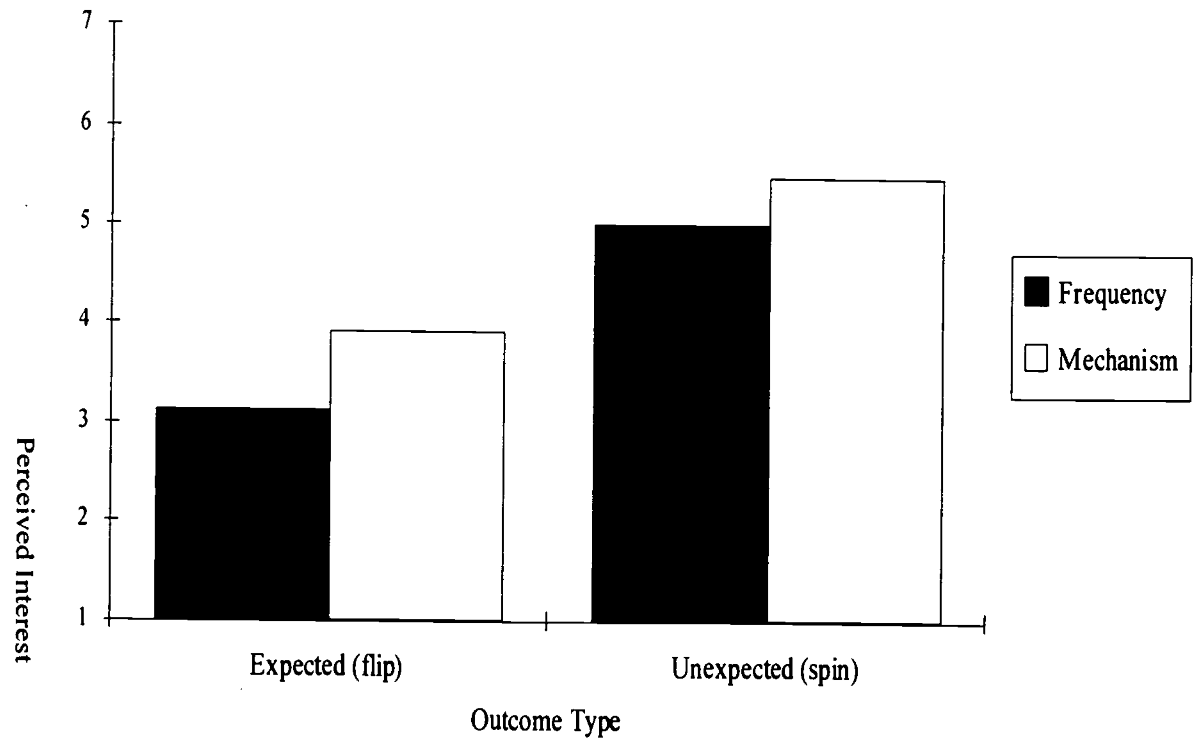
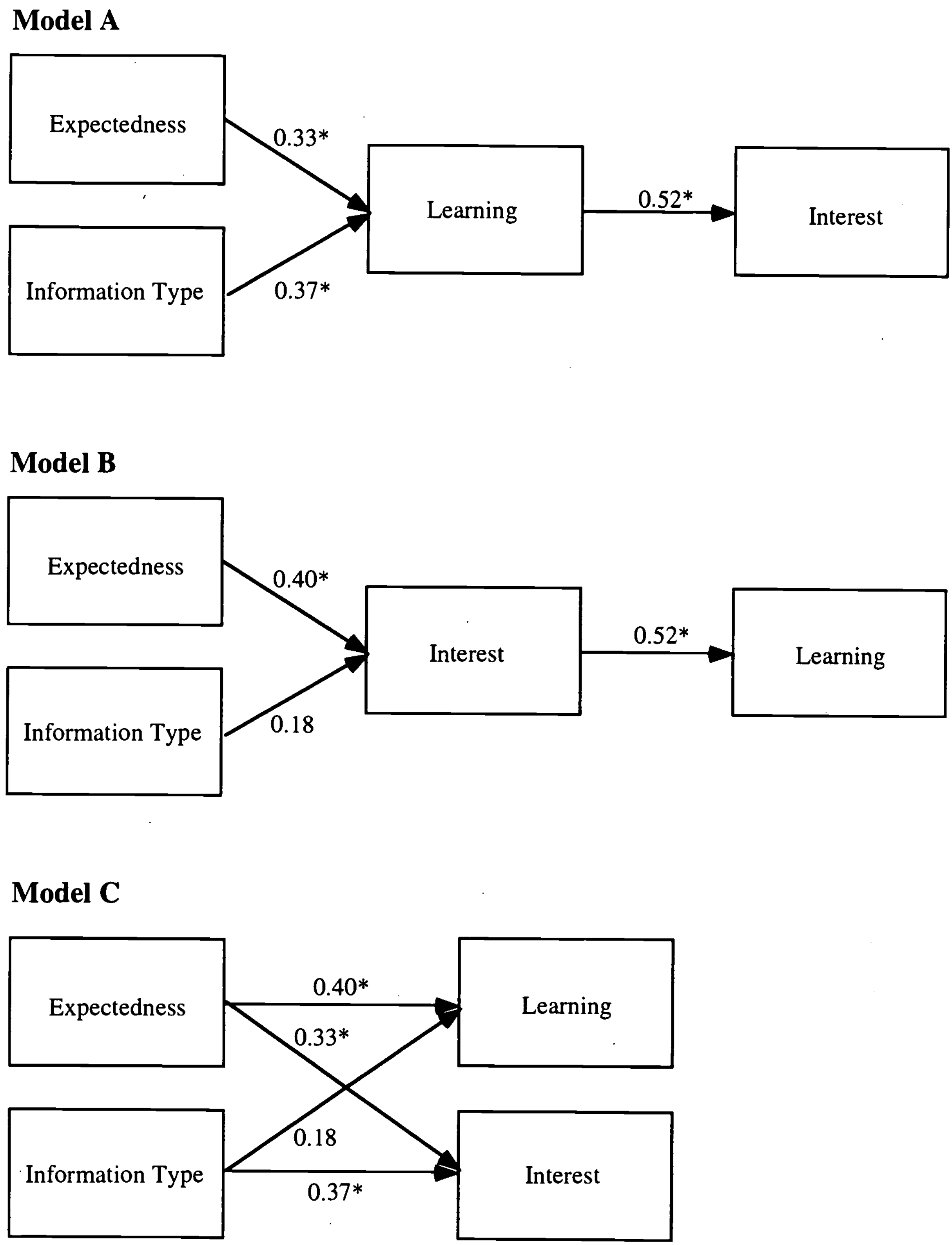


Figure 4: Three covariation matrix models, including standardized path estimates, from Experiment 1



Note. * indicates p < .05

Figure 5: Amount of perceived learning from the target passage as a function of expectedness of outcome and type of information in experiment 2.

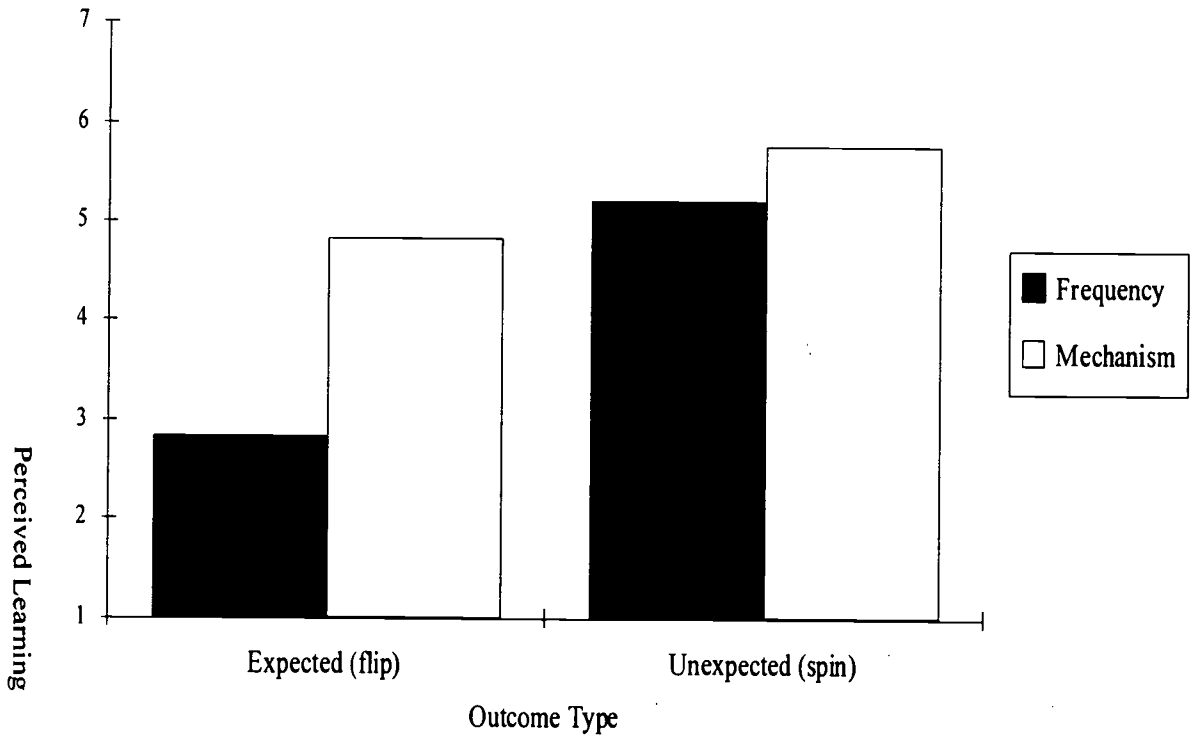


Figure 3: Amount of perceived interest for the target passage as a function of expectedness of outcome and type of information in experiment 2.

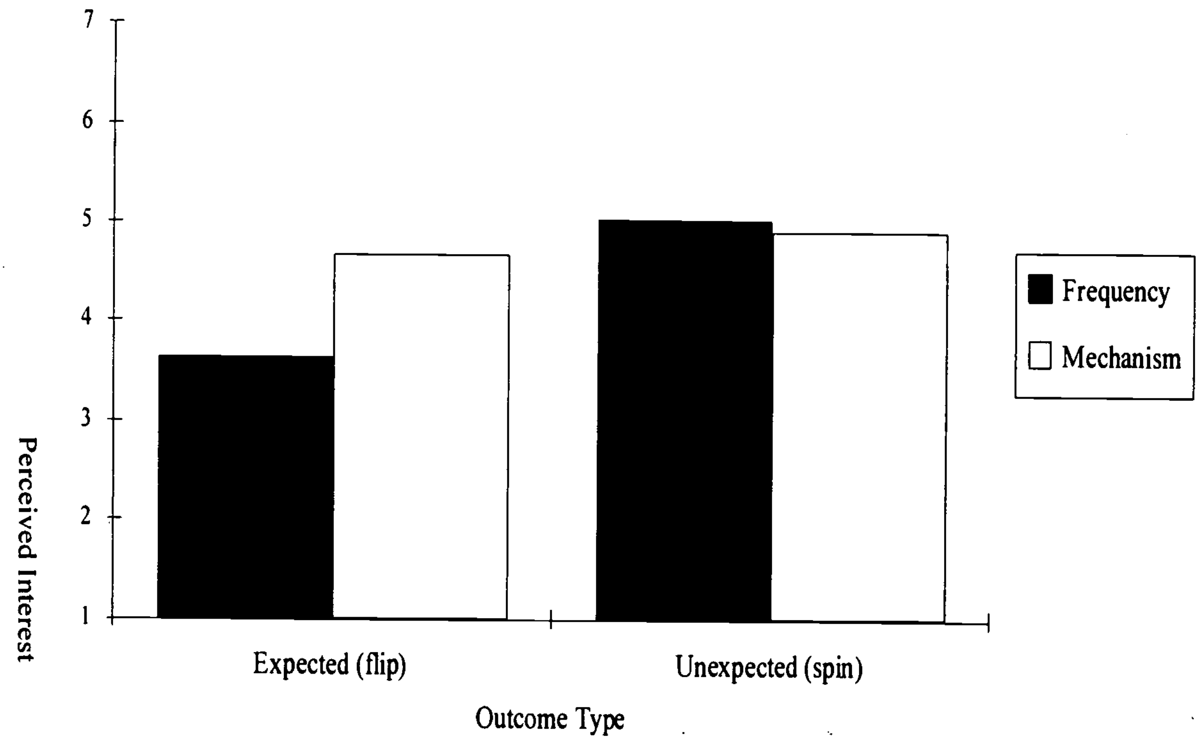
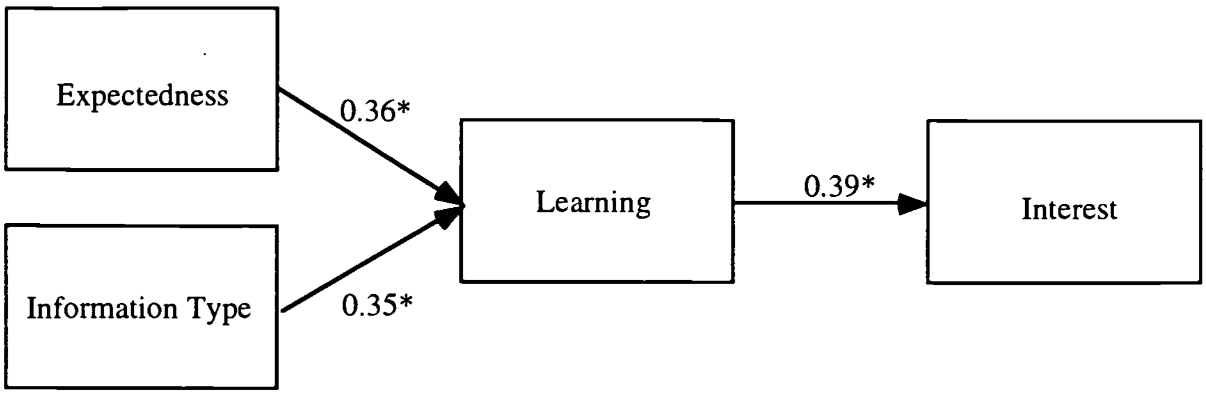
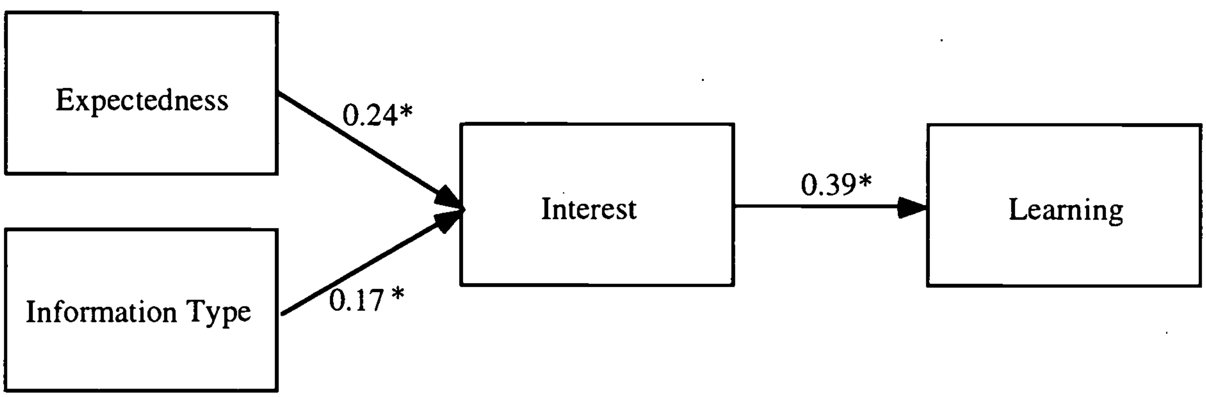


Figure 7: Three covariation matrix models, including standardized path estimates, from Experiment 2

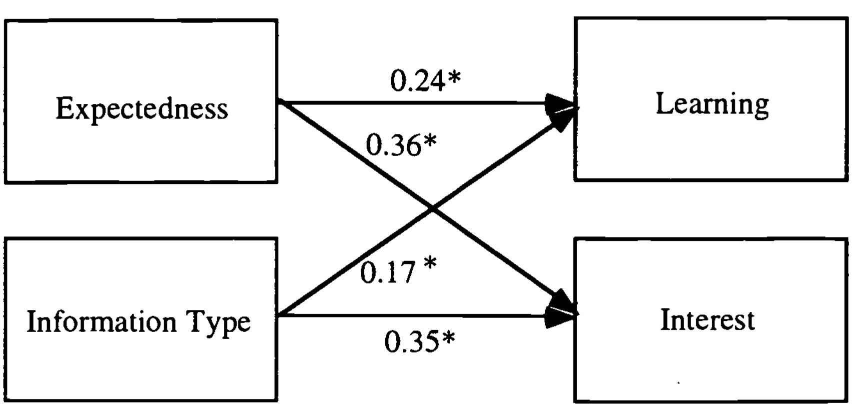
Model A



Model B



Model C



Note. * indicates $p < .05$

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